DUTCH ELM DISEASE AND ITS CONTROL

UNITED STATES DEPARTMENT OF AGRICULTURE

PREPARED BY SCIENCE AND EDUCATION ADMINISTRATION • FOREST SERVICE

AGRICULTURE INFORMATION BULLETIN No. 193

Use of Pesticides

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This use of pesticides is governed by the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended. This act is administered by EPA. According to the provisions of the act, "It shall be unlawful for any person to use any registered pesticide in a manner inconsistent with its labeling." (Section 12 (a) (2) (G).)

EPA has interpreted this section of the act to require that the intended use of the pesticide must be on the label of the pesticide being used or covered by a Pesticide Enforcement Policy Statement (PEPS) issued by EPA.

The optimum use of pesticides, both as to rate and frequency, may vary in different sections of the country. Users of this publication may also wish to consult their Cooperative Extension Service, State agricultural experiment stations, or county extension agents for information applicable to their localities.

The pesticides mentioned in this publication are available in several different formulations that contain varying amounts of active ingredient. Because of these differences, the rates given in this publication refer to the amount of active ingredient, unless otherwise indicated. Users are reminded to convert the rate in the publication to the strength of the pesticide actually being used. For example, 1 pound (0.45 kg) of active ingredient equals 2 pounds (0.90 kg) of a 50-percent formulation.

The user is cautioned to read and follow all directions and precautions given on the label of the pesticide formulation being used.

Federal and State regulations require registration numbers. Use only pesticides that carry one of these registration numbers.

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The pesticides mentioned in this publication were federally registered for the use indicated as of the issue of this publication. The user is cautioned to determine the directions on the label or labeling prior to use of the pesticide.

Washington, D.C.

Revised January 1979

☆ U.S. GOVERNMENT PRINTING OFFICE : 1978 O—274-646

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

Stock Number 001-000-03858-3

Dutch Elm Disease and Its Control

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Background

Dutch elm disease was discovered in Cleveland, Ohio, in 1930 and around the port of New York in 1933. The causal fungus, *Ceratocystis ulmi* (Buisman) C. Moreau, was introduced on elm-veneer logs imported from Europe. Soon the disease appeared along railroad rights-of-way and at ports of entry. Since then, it has spread and is reported in 42 States (fig. 1). The disease has caused extremely heavy losses of elms, *Ulmus,* both wild and those planted as shade trees. It is the most destructive shade-tree disease in North America. The fungus attacks all species of elms, but some are more susceptible than others. Trees in the related genera *Zelkova* and *Planera* have become diseased when artificially inoculated with the fungus.

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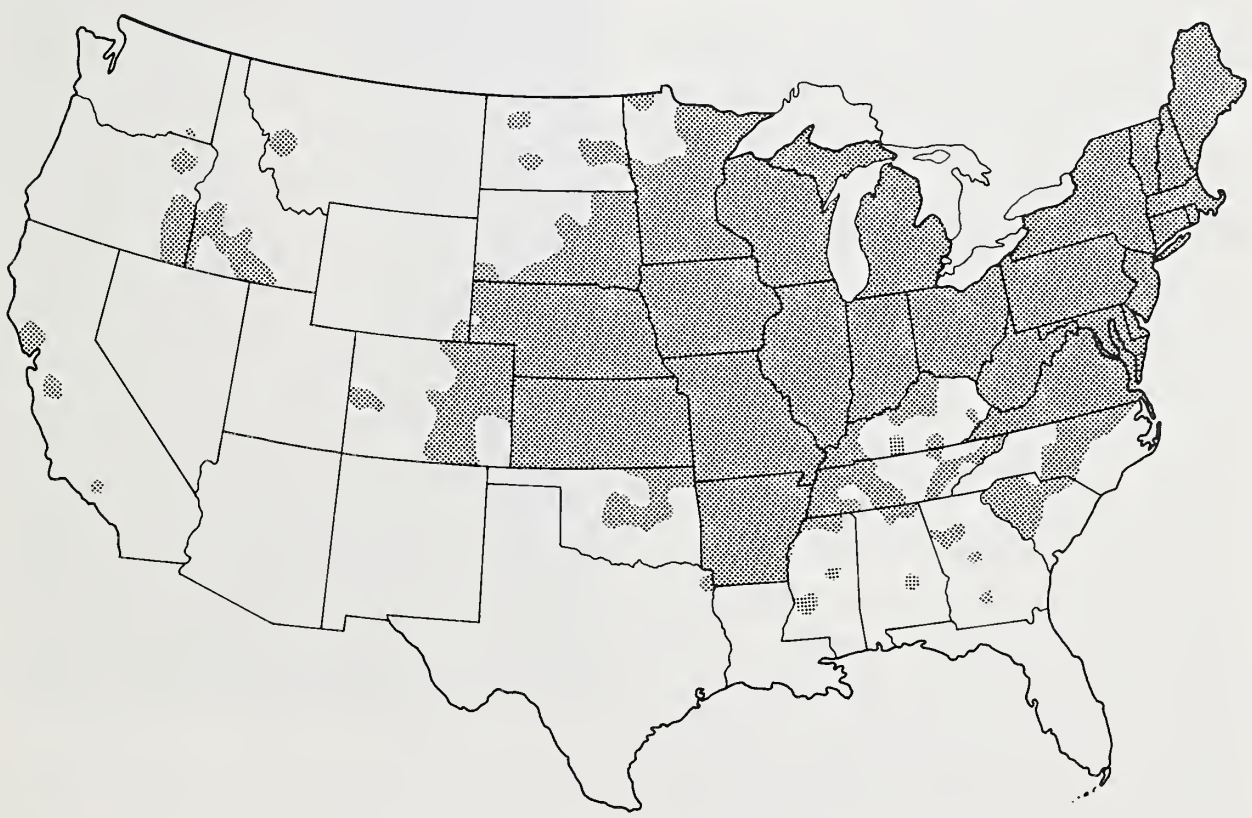

Figure 1.—Distribution of Dutch elm disease in the United States.

In the United States the principal carriers of the Dutch elm disease fungus are two species of elm bark beetles: the smaller European elm bark beetle, *Scolytus multistriatus* (Marsham), and the native elm bark beetle, *Hylurgopinus rufipes* (Eichhoff). The European species is by far the more common vector in most of the United States and usually displaces the native species.

Like the fungus, the smaller European elm bark beetle was introduced into the United States from Europe. This beetle was first reported near Boston, Mass., in 1909 and has since been reported from all States except Florida, Hawaii, and Alaska. The beetle is probably present wherever elms grow.

Symptoms

Dutch elm disease produces a wilting and yellowing or drying of foliage, usually followed by defoliation and death of the affected branches (cover photo). Trees affected by the Dutch elm disease develop a brown discoloration in the water-conducting vessels of the wood. This may be seen in the outer annual ring by cutting a diseased branch (fig. 2).

The disease symptoms usually appear first on one or several branches and then spread to other parts of the crown. Sometimes, however, the entire tree suddenly develops symptoms. Infected trees may die within a few weeks or gradually, branch by branch, over several years. Usually trees that become infected in the spring or early summer die quickly; those that become diseased in late summer may not die until the following year.

Dutch elm disease is one of several vascular wilt diseases attacking elm, all of which produce symptoms that look similar. Definite identification of these vascular wilt infections requires laboratory tests using specimens from the diseased tree. In some instances, the

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Figure 2.—Brown discoloration in the wood of infected twig.

Dutch elm disease fungus may not be found in these specimens even though the tree is affected by the disease.

Facilities for making necessary laboratory tests are available at State agricultural experiment stations or State departments of agriculture. These tests are rarely needed, however, if Dutch elm disease is known to be well established in your area.

Fungus Carriers

The adult smaller European elm bark beetle (fig. 3) feeds and breeds in elms. Beetles feed primarily on 2- to 4-year-old twig crotches of living elms (fig. 4). Beetles breed in dying or dead elm wood with intact bark. Healthy elms are readily attacked for feeding, but rarely for breeding. In the summer, complete development from egg to adult takes place in galleries under the bark (fig. 5) in about 6 weeks. *Immediate removal of dying elms, therefore, is important to reduce spread of the disease.*

Overwintering larvae (fig. 6) complete their development during the spring and emerge from the wood (fig. 7) as adults about the time elms break dormancy. Adults of the smaller European elm bark beetle feed during the entire growing season of the elm.

Because feeding beetles may carry the Dutch elm disease fungus on and in their bodies, they can cause the healthy tree to become infected. The highest disease incidence results from spring and early summer feeding. Spores of the Dutch elm disease fungus introduced into the spring-wood vessels are carried rapidly to other parts of the tree. Vessels produced later in the summer are shorter and smaller in diameter and may restrict movement of the fungus. This may delay the death of the tree.

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Figure 3.—Adult smaller European elm bark beetle.

Beetle emergence begins as early as April and continues through October. Adult elm bark beetles begin to breed soon after they emerge and breeding continues throughout the entire growing season of the elm. Thus, tremendous increases in the number of bark beetles can occur in recently killed, cut, or damaged elm trees.

Reservoirs of fungus (fig. 8) may become established in brood galleries. Adult beetles that emerge from these galleries may carry spores and introduce them into healthy elms when they feed. In this way the Dutch elm disease fungus may be moved long distances any time during the entire active period of the adult beetle.

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Figure 4.—Adult smaller European elm bark beetle feeding in a twig crotch. Elms may be infected with Dutch elm disease through these feeding injuries.

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Figure 5.—Brood galleries of the smaller European elm bark beetle on the surface of the wood. The vertical galleries are constructed by the breeding adults and the radiating galleries by the feeding larvae.

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Figure 6.—Larvae of the smaller European elm bark beetle in feeding galleries in inner bark.

Root-Graft Spread

Root grafts occur between elms growing near one another. The prevalence of root grafts is influenced by the proximity of the trees and soil conditions. The fungus spreads from diseased to healthy trees through these grafts. The extent of spread through root grafts varies, but it is considered to be important, especially where large infected trees are within 35 to 50 feet (11 to 15 m) of healthy ones.

Control

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Figure 7.—Smaller European elm bark beetle emergence holes. As many as 2,000 adults can emerge from 1 square foot (0.09 m^2) of bark. The usual number is about 400.

Federal and State research workers have studied Dutch elm disease since 1931. Their goal is to find effective and economical means for reducing the tremendous losses caused by this disease. At present there are four ways to combat Dutch elm disease:

1. Reduce the population of beetles by eliminating elm material required for breeding. This is a matter of sanitation and tree care.

2. Protect healthy elms from feeding beetles. This is done by spraying with an insecticide.

3. Prevent underground transmission of the fungus from a diseased tree to adjacent healthy trees. This is accomplished by destroying all grafted roots.

4. Plant trees that are resistant to Dutch elm disease. Lists of trees suitable for your area are available from your State agricultural experiment station or Cooperative Extension Service.

The heavy loss of elms from Dutch elm disease has created a market for protective and curative treatments. Many have been tested, but most have proved to be of no practical value. In fact, some of these treatments caused serious tree injury. Do not invest in Dutch elm disease cures without first investigating their effectiveness through

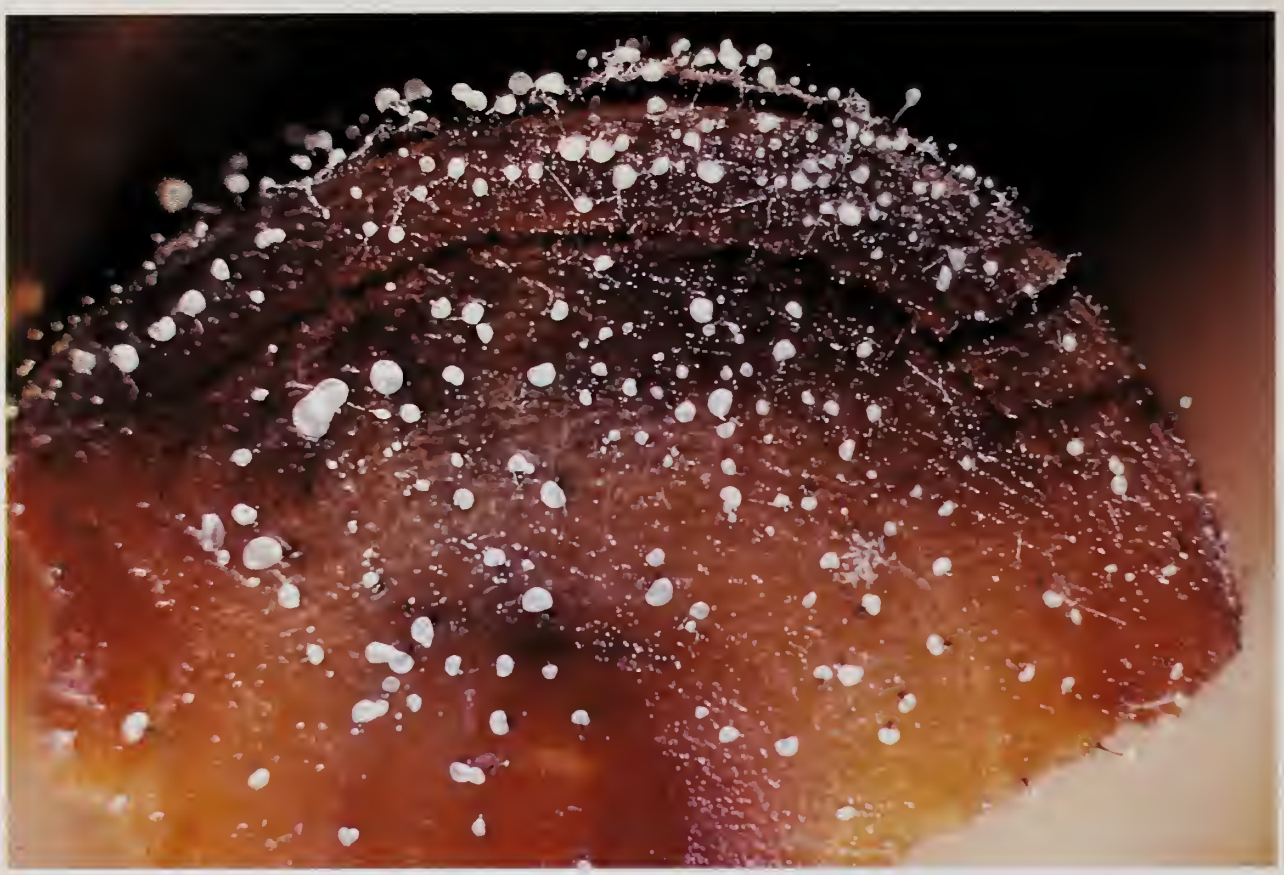

Figure 8.—Fungus spores developing on wood of diseased elm. Each white glob consists of large numbers of fungus spores in a sticky matrix that clings to the adult beetle when it emerges from the bark.

your State department of agriculture or State agricultural experiment station.

Sanitation and Tree Care

Sanitation is the most important control for Dutch elm disease. Sanitation is most effective when started early, preferably as soon as bark beetles invade an area. DO NOT WAIT UNTIL THE DISEASE IS PRESENT BEFORE UNDERTAKING A SANITATION PROGRAM. Sanitation must be practiced for the following reasons:

1. **Sanitation prevents** the rapid increase of bark beetles. An early start in reducing their numbers can delay or reduce the occurrence of diseased trees.

2. **Sanitation reduces** the number of bark beetles and hence increases the effectiveness of sprays.

3. **Sanitation destroys** reservoirs of the Dutch elm disease fungus.

4. **Sanitation eliminates** dead and dying parts that harbor other injurious fungi and insects.

To break the fungus-beetle cycle (fig. 9), a five-step sanitation program should be followed:

1. **Survey all elms** for Dutch elm disease symptoms. Surveys should begin in the spring and should continue as frequently as possible throughout the growing season.

2. **Destroy all symptomatic elms** found between April and September within 30 days. This will prevent their colonization by beetles that later carry the fungus to healthy elms.

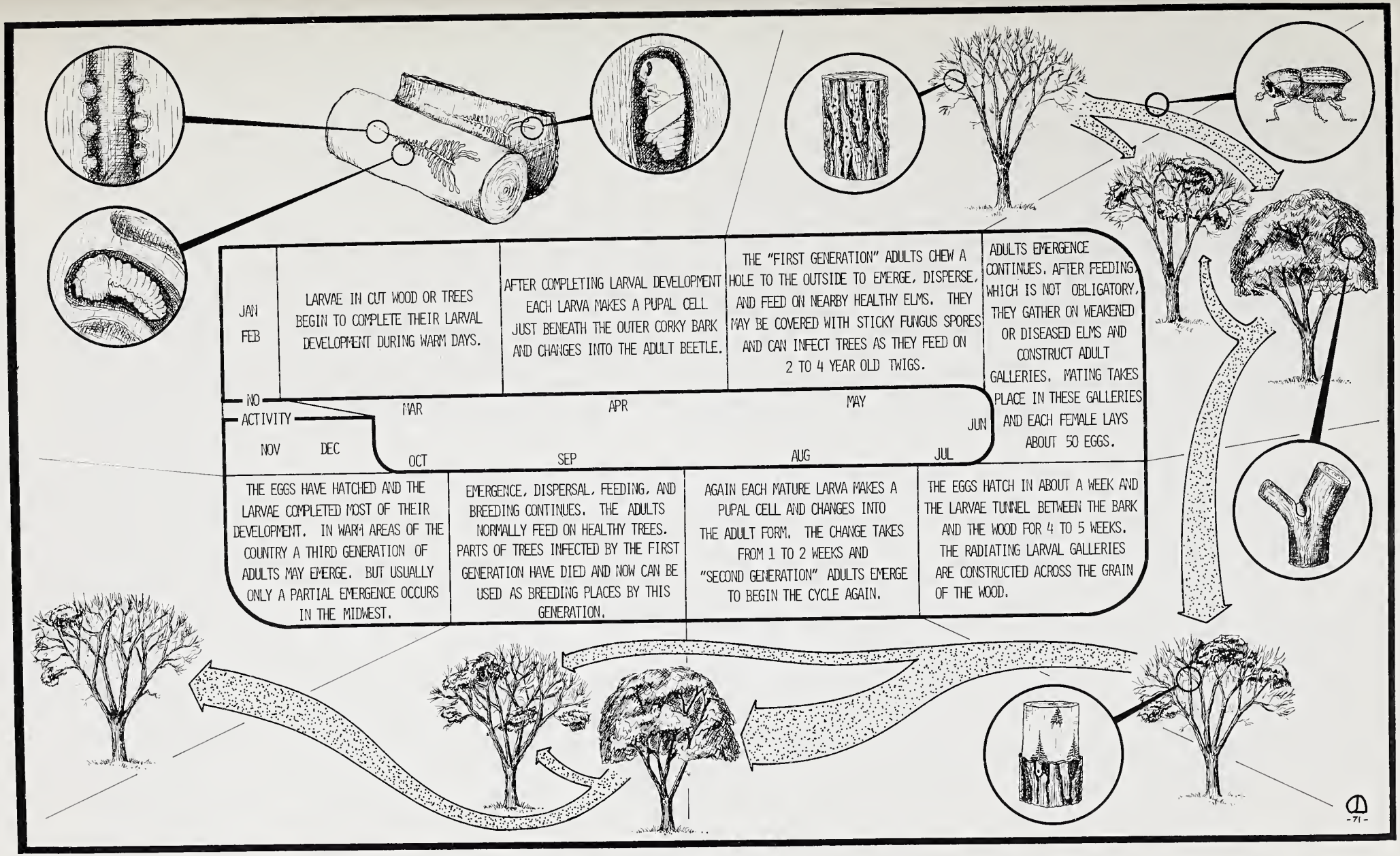

Figure 9.—The fungus-beetle cycle. Variations in timing may occur in different geographic locations.

3. **Destroy all elm wood that may serve as breeding sites** for the elm bark beetle. This includes entire elm trees or large branches that have been weakened, recently injured, or killed by drought, storms, or disease. Proper disposal of infested elm wood consists of removing all bark, or burning it, or burying it in sanitary land fills.

4. **Carry on sanitation in stands of low-value elms** as conscientiously as in stands of high-value elms.

5. **Systematically search out and destroy bark beetle breeding places.** In addition to standing trees, beetles may lay eggs and produce young in piles of elm logs and in stumps.

Tree care should be practiced to insure healthy elms. Periodic pruning removes wood that may serve as breeding sites for beetles or as entrance sites for organisms that cause diseases. Pruning also eliminates branches that may break in wind or ice storms and thus cause dangerous wounds. However, do not prune elms during the summer when beetles are abundant and may be attracted to the pruning wounds. Pesticides may be needed to control insects and diseases that reduce a tree's vigor. Trees planted in poor sites may need fertilizing and watering to retain normal growth and vigor.

Trees should be protected from frequent or severe mechanical injury. Lawnmower damage may be reduced by removing the sod from around the base of the tree or by constructing tree boxes to reduce mechanical injury to the trunk.

Spraying with Methoxychlor

Research in the control of Dutch elm disease by the U. S. Department of Agriculture and State agencies has resulted in the development of a spray program designed to minimize the loss of elm trees from Dutch elm disease and to reduce environmental pollution.

Spray equipment and spray.— Sprays for controlling elm bark beetles may be applied using either hydraulic sprayers or mist blowers. For best results, use hydraulic sprayers having an output of 60 gallons per minute (220 L/min) at pressures up to 600 pounds per square inch (42 kg/cm^2) or mist blowers with an air output of 25,000 cubic feet per minute (700 m^3/min) and a nozzle velocity of 100 miles per hour (160 km/h). Mist blowers should be capable of a spray output of at least 1 gallon per minute (3.8 L/min).

The approved rates of methoxychlor for dormant applications are a 2 percent emulsion for hydraulic sprayers and a 12½ percent emulsion for mist blowers. For hydraulic sprayers, mix 8 gallons (30 L) of 25 percent methoxychlor EC (emulsifiable concentrate) with water to make 100 gallons (380 L) of finished spray. For mist blowers, mix 5 gallons (19 L) of 25 percent methoxychlor EC with water to make 10 gallons (38 L) of finished spray. These or similar directions are listed on each methoxychlor container. To reduce damage to painted metal surfaces, a fast-breaking horticultural white oil should be mixed (10 percent by volume) with the finished spray.

When hydraulic spray equipment is

used, enough spray should be applied to wet all bark surfaces thoroughly, but run-off should be avoided. This usually requires from 20 to 30 gallons (76 to 110 L) for an average 50-foot (15 m) elm tree. When mist blowers are used, spray deposits dry so rapidly that no run-off occurs. Between 2 and 3 gallons (7.6 to 11 L) of spray are needed to adequately treat a 50-foot (15 m) tree.

How and when to spray.—All bark surfaces must be completely covered with spray to prevent bark beetle feeding. *Thoroughness is important.* Special care should be taken to secure good coverage in the upper part of the tree.

Spray coverage can be greatly improved if two men work as a team. One man sprays while the other observes from a distance to assure complete coverage. Emulsion-type sprays dry very rapidly, and unless it rains within an hour after spraying, there is little loss of deposit from washing.

Elm trees must be sprayed before the smaller European elm bark beetle becomes active in the spring. Spraying should be done on days that have little or no wind, no rain within 1 hour after spraying and temperatures above freezing. Spray applications made anytime during the dormant period (fall, winter, or spring) will remain effective during the period of bark beetle activity.

See pesticide precautions inside front cover.

Control of Root-Graft Spread

Root grafts may develop between elms when their roots come in contact. If a tree becomes infected with Dutch elm disease, the fungus may spread to healthy trees through root grafts. Once the disease has become established, a major portion of subsequent tree mortality may result from root-graft spread.

To prevent root-graft transmission, a chemical or mechanical barrier that destroys the graft must be established between diseased and healthy trees. A chemical barrier can be made by injecting a soil fumigant such as metham (sodium n-methyldithiocarbamate) as soon as Dutch elm disease symptoms appear. To do this, drill ½- to 1-inch (1.25 to 2.5 cm) holes 15 to 30 inches (38 cm to 75 cm) deep and 5 to 10 inches (12.5 to 25 cm) apart in a single line midway between diseased and adjacent healthy trees. The holes should extend out well beyond the drip line of the crown. Metham normally is prepared by mixing one part chemical and four parts water. Pour about 1 cup of the solution into each hole. Seal the hole with soil. To avoid danger, follow the directions on the label.

A mechanical barrier can be made by digging a narrow trench 30 inches (75 cm) deep between the diseased and next two healthy trees. The trench should extend midway between the diseased and healthy trees, beyond their drip lines. Existing root grafts will be broken and this will prevent the Dutch elm disease fungus from growing from the diseased into the healthy elm.

CAUTION: Before drilling holes or digging trenches to establish chemical or mechanical barriers, be sure to locate possible underground obstructions such as utility pipes and wires.

Planting Resistant Elms

Although elm species vary greatly in their susceptibility to Dutch elm disease, none are immune. Unfortunately, the American elm (*Ulmus americana* L.), our most valuable native elm tree, is one of the most severely affected. The Siberian elm (*U. pumila* L.) and the Chinese elm (*U. parvifolia* Jacq.) are the most disease resistant of the elm species. The genera *Planera* and *Zelkova*, related to the elms, are also resistant.

Despite their susceptibility to Dutch elm disease, elms have many desirable characteristics that make them valuable shade and landscape trees. They are hardy in a wide range of climatic conditions; many of them have attractive forms and rapid growth rates; and they adapt well to the rigors of urban environments. For these reasons, the U.S. Department of Agriculture and State experiment stations have been conducting research to develop selections of elm that are resistant to Dutch elm disease.

Investigators in the Netherlands have found several elms with a high degree of disease resistance among commonly susceptible European elm species. One of these, the 'Christine Buisman' elm (a selection of *U. carpinifolia* Gleditsch), has been tested in this country and released for sale. Other more promising selections that are resistant to Dutch elm disease have been developed in this country and abroad. They are being tested for their adaptability to environmental conditions in North America and for their resistance to native pests. One of these, the 'Urban' elm (fig. 10), was developed by the U.S. Department of Agriculture and has been released to the nursery industry.

Conclusion

The tremendous loss of elms from Dutch elm disease points up an important lesson to be learned from the extensive planting of a single shade-tree species. The losses caused by Dutch elm disease have far outweighed the uniformity and neatness gained by the widespread planting of American elms. By carefully selecting a mixture of species and alternating these from block to block in street-tree plantings, uniform appearance can be retained, and losses caused by insects and diseases can be kept to a minimum.

Acknowledgments

The authors acknowledge R. R. Whitten (deceased) and R. U. Swingle (deceased) upon whose work this revision was based. We are especially grateful to J. H. Barger for information on control of elm bark beetles. We thank G. W. Peterson, W. E. Wallner, J. A. Weidhass, Jr., and R. G. Doerner for their contributions.

Figure 10.—The 'Urban' elm, a disease-resistant tree resulting from a cross between an Asiatic and a European elm.